Unionville, Missouri
Water Supply Study
Lake Mahoney

Lake Mahoney is located 2 miles North of Unionville in central Putnam County. Its drainage area is part of Thunderhead Reservoir drainage area and Lake Mahoney has a drainage area of 2.97 Square Miles. The lake is in the Blackbird Wildcat Creek Watershed.

Average annual rainfall is 37.2 inches. Annual rainfall for 1953 through 1957 is 24.1, 33.6, 39.4, 25.59, and 47.1 inches.

Two analysis were made:

1. First run was with the 2000 demand of 0.382 million gallons per day.
2. The lake was analyzed for the optimum daily use without emptying the lake during the evaluation period. Optimum demand is 0.283 million gallons per day.

Lake Mahoney analysis consisted of using the NRCS's computer program "RESOP". This program analyses remaining stored water at the end of each month by summing gains and losses.

Following is the data and procedures for input to the "RESOP" program.

STO-AREA Elevation-Storage and Elevation-Area data were determined from April 6, 2004 survey made by USGS.

Lake Mahoney

Unionville Water Supply

Elevation Feet	Area Acres	Volume Ac. Ft.	
959	1.1	0.3	
961	7.4	8.5	
963	14.4	30.2	
965	21.8	66.2	
967	31.1	120	
969	39.1	190	
971	45.9	270	
973	52.5	370	
975	60.1	490	
977	72.3	620	Top of Spillway Structure
977.3	75.5	640	Water surface on April 6, 2004
979	98.0	790	
981	129.0	1020	
985	154.0	1580	
987	168.0	1900	
989	183.0	2250	
989.5	187.0	2360	Top of Dam

LIMITS

Full pool storage 620 Ac.Ft.
Minimum pool storage 120 Ac.Ft.

Starting storage was considered at full pool elevation.

The Drainage area of the lake is 2.97 square miles.

GENERAL

The adjustment factor of 0.76 to convert from pan evaporation to lake evaporation was applied prior to entering the data for the control word EVAP. As a result a factor of 100 is applied.

The record period of drought is in the 1950's.
Analysis began in January 1951 and ended December 1959.

SEEPAGE

The reservoir seepage varied from 0 seepage near empty to a maximum of 1.0 inch per month when at full pool. The material in the dam is compacted earth of clayey soils.

RAINFALL

Rainfall data came from the Unionville, Mo. rain gage for the period 1951 through 1959.

RUNOFF

This is the runoff into the lake from its drainage area. Monthly runoff volumes in watershed inches were determined and comparisons were made for the Locust Creek River Gage at Linneus, Medicine Creek near Galt, and South Fork Chariton River near Promise, Iowa. The three gages yielded similar monthly runoff volumes. The South Fork Chariton River gage did not have enough years of data to evaluate the drought of record. After these comparisons, Locust Creek gage was chosen to represent runoff for the watershed.

In cases where rainfall to runoff values did not appear reasonable, adjustments were made for that month by looking at individual rains and estimating antecedent moisture and then, adjusting runoff based on NRCS's runoff curve numbers.

EVAP.

Pan evaporation at the Lakeside gaging station was used as a base because it has data for year around evaporation. All other stations only measure data between April through November. Lakeside data was updated during these months with gage data from stations at New Franklin, and Columbia. Depending on the latest data for the station nearest to Unionville.

DEMAND

Determined from city records. The total use in 2000 was 139,500,000 gallons which amounts to 0.382 million gallon per day.

Lake Thunderhead
Putnam County, Missouri
Water Supply Study

Lake Thunderhead is a privately owned lake located 5 miles North of Unionville in central Putnam County. It's total drainage area is 25.97 square miles. Unionville's Lake Mahoney makes up 2.97 square miles of the drainage area. The lake is in the Blackbird Wildcat Creek watershed.

Average annual rainfall at Unionville is 37.2 inches. Annual rainfall for 1953 through 1957 is 24.1, 33.6, 39.4, 25.59, and 47.1 inches.

Lake Thunderhead was not designed for water supply. It only serves as a supplemental supply during periods of drought. It is downstream of Lake Mahoney. Spillage from Lake Mahoney was added to the inflow to Lake Thunderhead.

Four analysis were made:

1. First run was to optimize the potential demand through the drought of record in the 1950's. Lake Thunderhead and Lake Mahoney availability of water was optimized. Lake Mahoney's optimum demand = 0.283 MGD and Lake Thunderhead demand was 3.36 MGD.
2. The second run assumes that none of Unionville demand comes from Lake Mahoney and all of the year 2000 demand of 0.382 MGD came from Lake Thunderhead. The water surface elevation in Lake Thunderhead would reach 3.5 feet below the spillway.
3. The third run assumed that optimum demand (0.283 MGD) came from Lake Mahoney and none came from Lake Thunderhead. Losses in Lake Thunderhead would be evaporation and seepage. The result would be the water surface would be expected to reach 2.9 feet below the spillway.
4. The fourth run assumed that the optimum demand of 0.283 MGD came from Lake mahoney and 0.099 MGD came from Lake Thunderhead, meeting the 2000 demand for Unionville of 0.382 MGD. The result would be the water surface would be expected to reach 3.1 feet below the spillway.

All spillage from Lake Mahoney was added to inflow for Lake Thunderhead.

Lake Thunderhead analysis consisted of using the NRCS's computer program "RESOP". This program analyses remaining stored water at the end of each month by summing gains and losses. See Unionville study for Lake Mahoney analysis and input data. Lake Thunderhead has the potential to supply an optimum yield of 3.361 million gallons per day.

Following is the data and procedures for input to the "RESOP" program.

STO-AREA Elevation-Storage and Elevation-Area data were determined from April 6, 2004 survey made by USGS.

Lake Thunderhead

Elevation (feet)	Area (acres)	Volume (acre-ft)
932.0	16.8	10.1
934.0	48.7	76.5
936.0	78.0	202
938.0	118	398
940.0	162	678
942.0	208	1,050
944.0	260	1,510
946.0	304	2,080
948.0	356	2,740

950.0	412	3,500	
952.0	476	4,390	
954.0	537	5,400	
956.0	598	6,540	
958.0	660	7,800	
960.0	721	9,180	
962.0	791	10,690	
964.0	864	12,340	
966.0	940	14,140	
967.3	989	15,400	Spillway elevation
967.8	1,010	15,900	Water surface elevation April 2004
968.0	1,040	16,100	
970.0	1,100	18,240	
971.3	1,140	19,690	Emergency spillway elevation

LIMITS Full pool storage 15,400 Ac.Ft.
Minimum pool storage 1500 Ac.Ft.

Starting storage was considered at full pool elevation.

The net drainage area, after subtracting Lake Mahoney drainage area, is 22.96 square miles.

GENERAL The adjustment factor of 0.76 to convert from pan evaporation to lake evaporation was applied prior to entering the data for the control word EVAP. As a result a factor of 100 is applied.

The record period of drought is in the 1950's.
Analysis began in January 1951 and ended December 1959

SEEPAGE The reservoir seepage varied from 0 seepage near empty to a maximum of 3.0 inch per month when at full pool. The material in the dam is compacted earth of clayey soils.

RAINFALL Rainfall data came from the Unionville, Mo. rain gage for the period 1951 through 1959.

RUNOFF This is the runoff into the lake from its drainage area. Monthly runoff volumes in watershed inches were determined and comparisons were made for the Locust Creek Stream Gage at Linneus, Medicine Creek near Galt, and South Fork Chariton River near Promise, Iowa. The three gages yielded similar monthly runoff volumes. The South Fork Chariton River Gage did not have enough years of data to evaluate the drought of record. After these comparisons, Locust Creek Gage was chosen to represent runoff for the watershed.

In cases where rainfall to runoff values did not appear reasonable, adjustments were made for that month by looking at individual rains and estimating antecedent moisture and then, adjusting runoff based on NRCS's runoff curve numbers.

EVAP Pan evaporation at the Lakeside gaging station was used as a base because it has data for year around evaporation. All other stations only measure data between April through November. Lakeside data was updated during these months with gage data from stations at New Franklin, and Columbia. Depending on the latest data for the station nearest to Unionville.

DEMAND The demand was calculated to determine the capabilities of the lake to meet local needs. Unionville demand for year 2000 was 0.382 MGD. Runs were made to determine effects of three different scenarios of combinations of withdrawal.

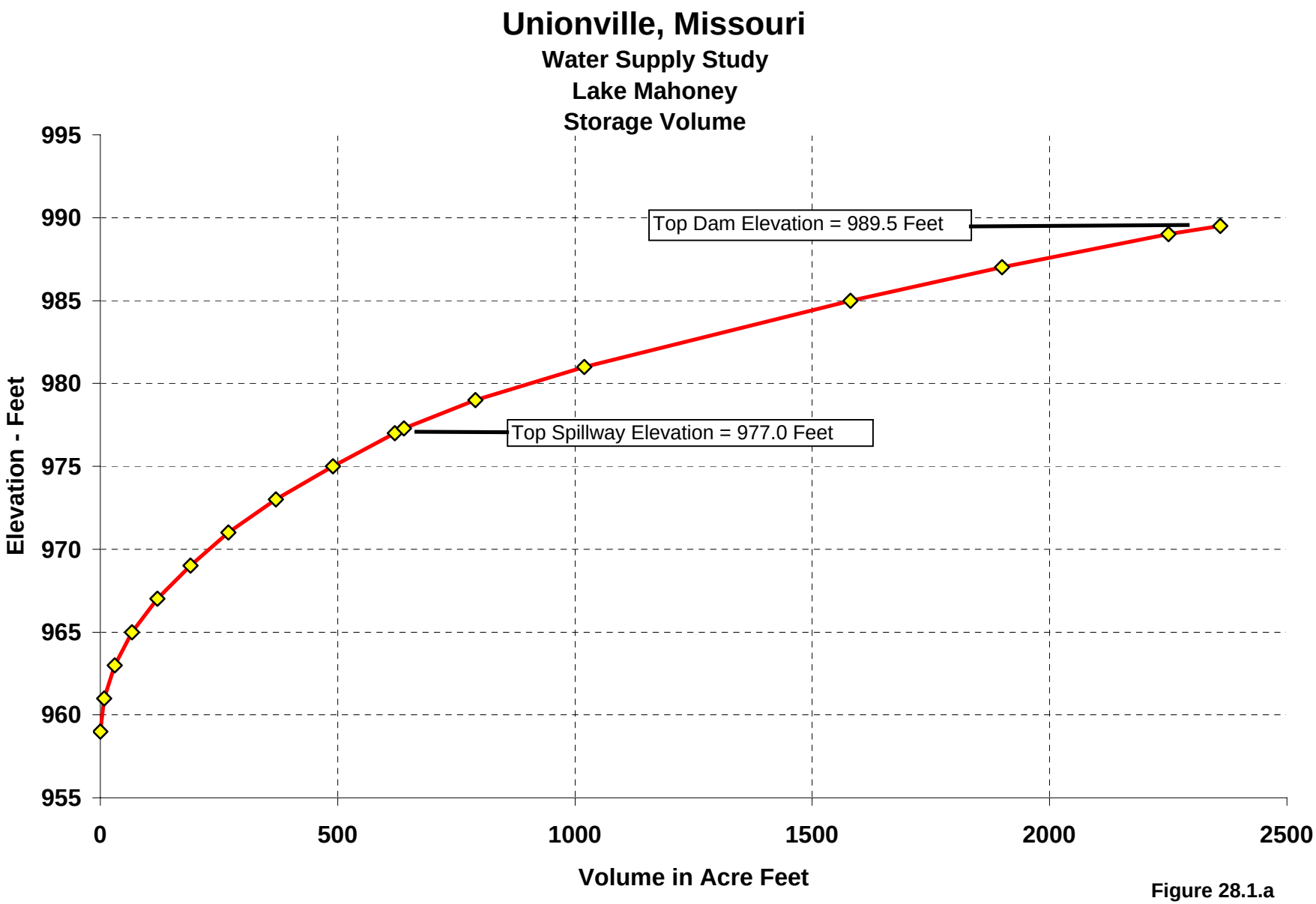

Unionville, Missouri
Water Supply Study
Lake Mahoney
Storage Volume
Top Dam Elevation = 989.5 Feet
Top Spillway Elevation = 977.0 Feet
Elevation - Feet
995
990
985
980
975
970
965
960
955
0
500
1000
1500
2000
2500
Volume in Acre Feet

Figure 28.1.a

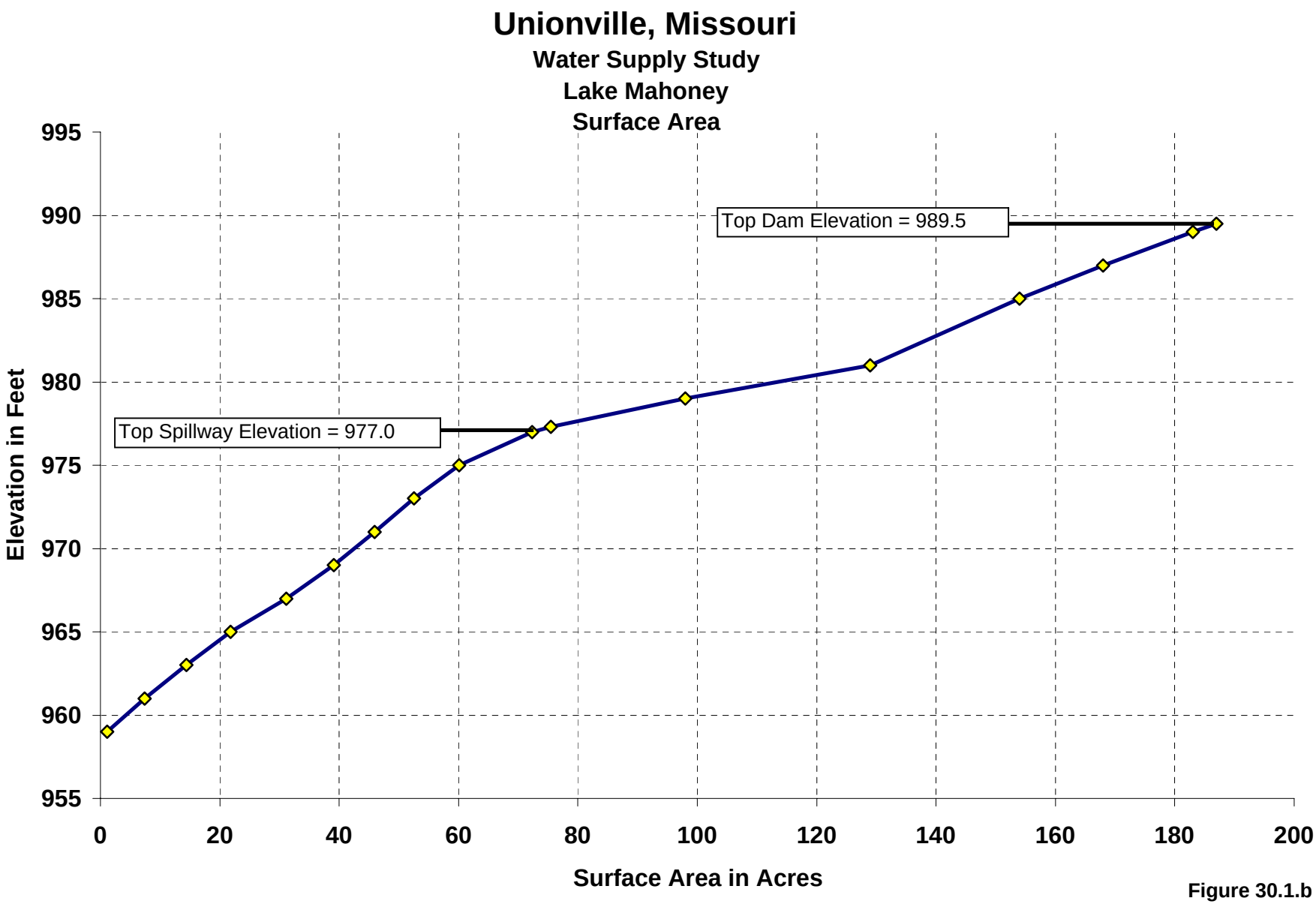

Unionville, Missouri
Water Supply Study
Lake Mahoney
Surface Area
Top Dam Elevation = 989.5
Top Spillway Elevation = 977.0
Elevation in Feet
995
990
985
980
975
970
965
960
955
0
20
40
60
80
100
120
140
160
180
200
Surface Area in Acres

Figure 30.1.b

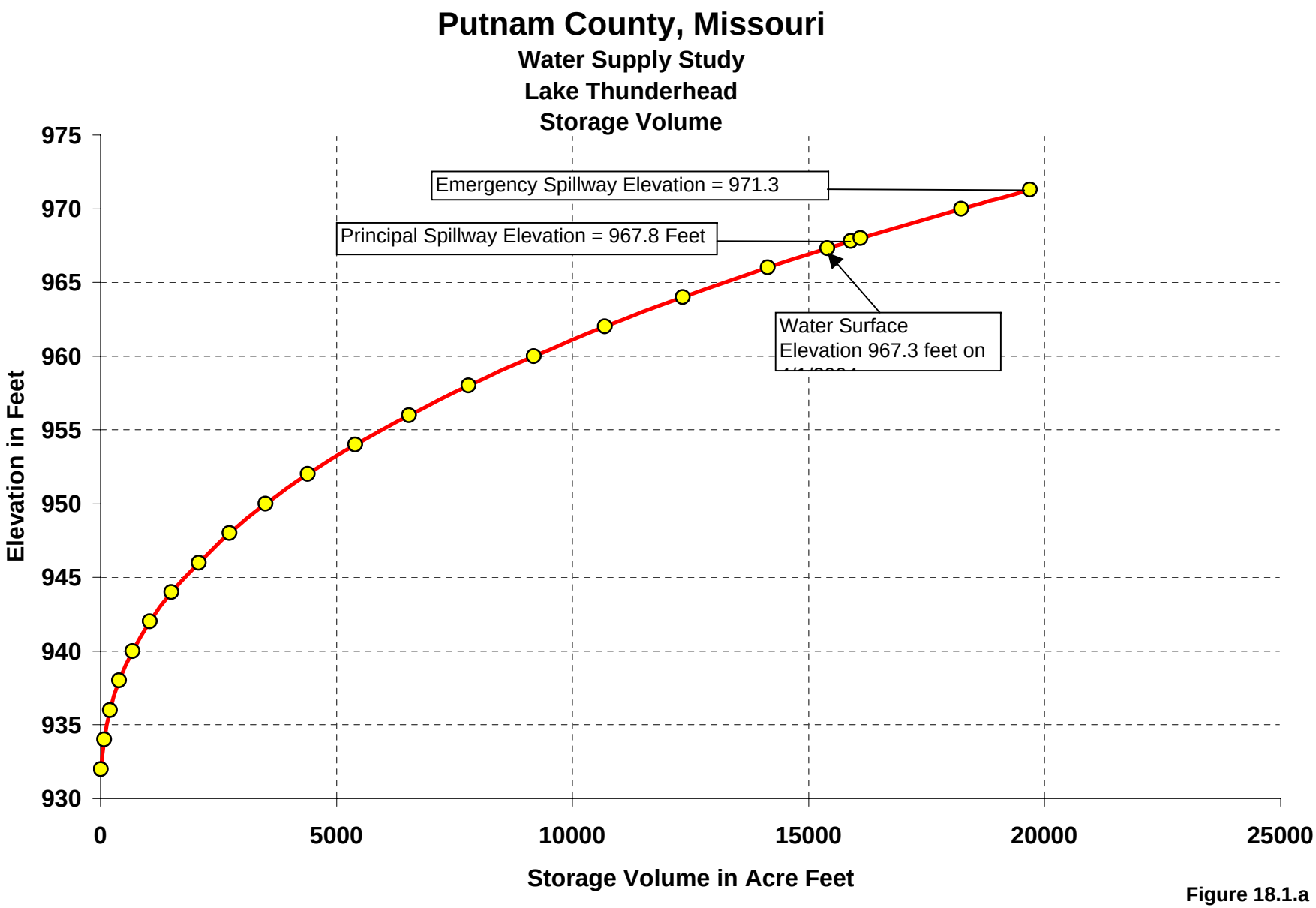

Putnam County, Missouri
Water Supply Study
Lake Thunderhead
Storage Volume
Emergency Spillway Elevation = 971.3
Principal Spillway Elevation = 967.8 Feet
Water Surface
Elevation 967.3 feet on
Elevation in Feet
975
970
965
960
955
950
945
940
935
930
0
5000
10000
15000
20000
25000
Storage Volume in Acre Feet

Figure 18.1.a

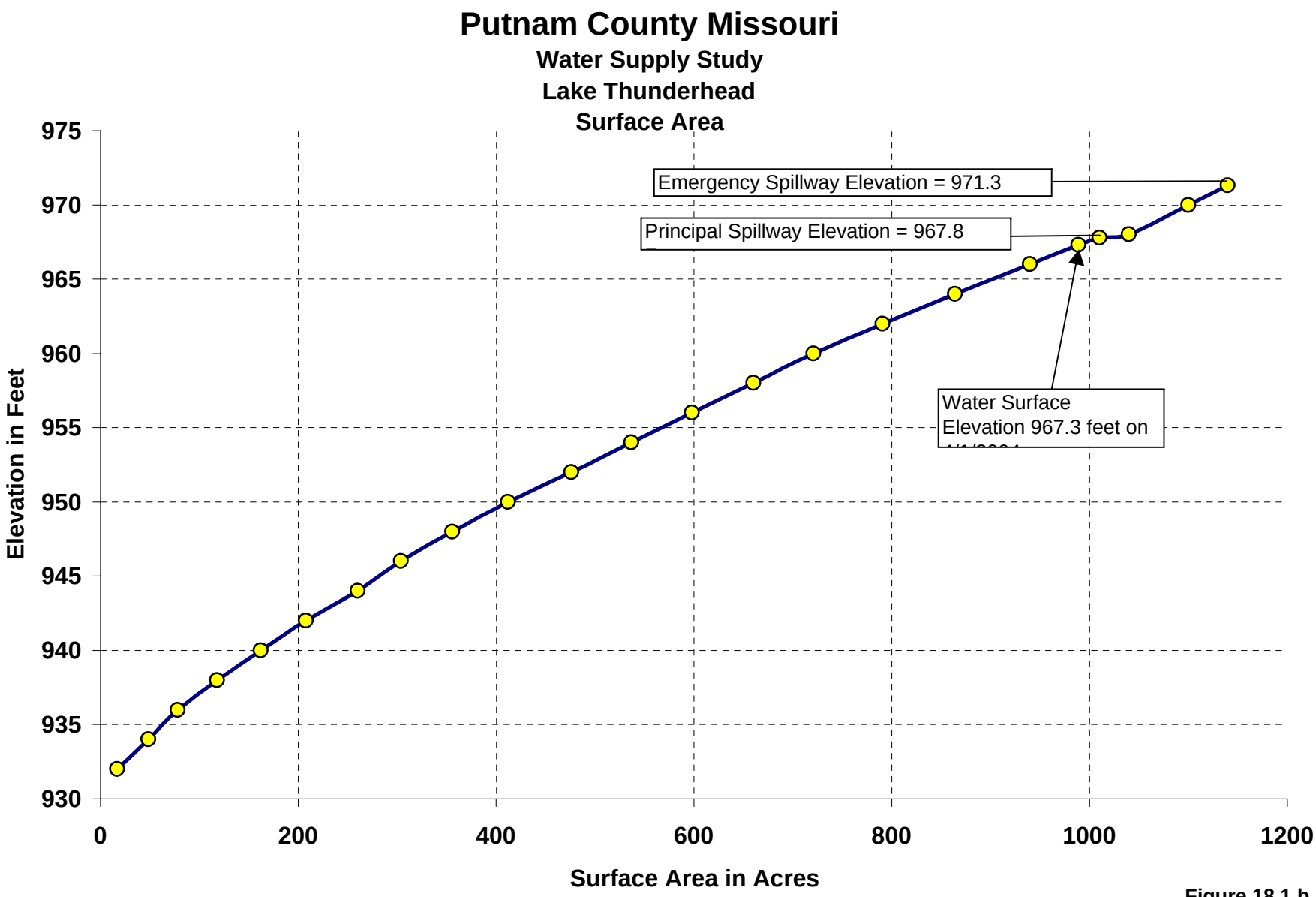

Putnam County Missouri
Water Supply Study
Lake Thunderhead
Surface Area
Emergency Spillway Elevation = 971.3
Principal Spillway Elevation = 967.8
Water Surface
Elevation 967.3 feet on
Elevation in Feet
975
970
965
960
955
950
945
940
935
930
0
200
400
600
800
1000
1200
Surface Area in Acres

Figure 18.1.b

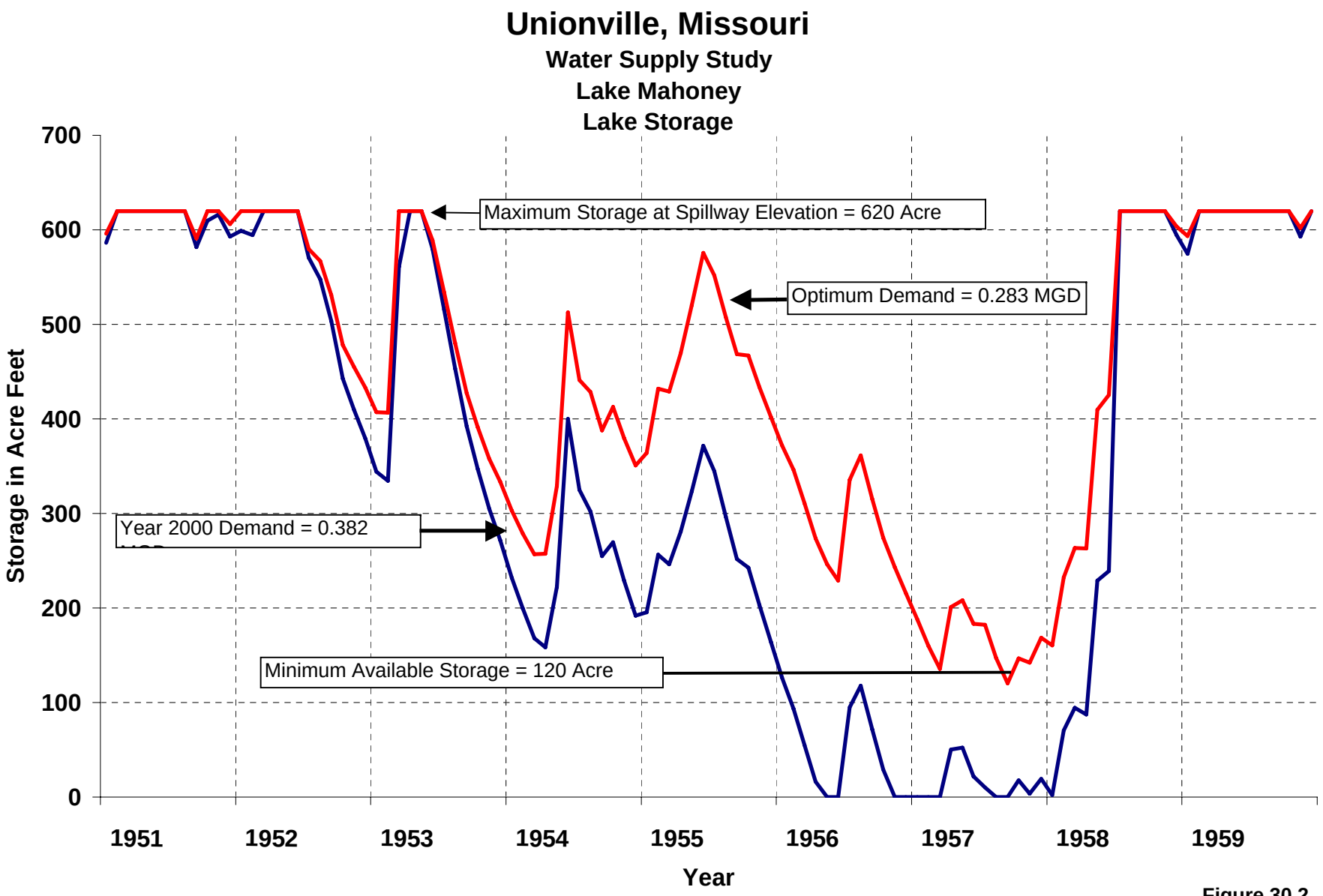

Unionville, Missouri
Water Supply Study
Lake Mahoney
Lake Storage
Storage in Acre Feet
700
600
500
400
300
200
100
0
1951
1952
1953
1954
1955
1956
1957
1958
1959
Year
Maximum Storage at Spillway Elevation = 620 Acre
Optimum Demand = 0.283 MGD
Year 2000 Demand = 0.382
Minimum Available Storage = 120 Acre

Figure 30.2

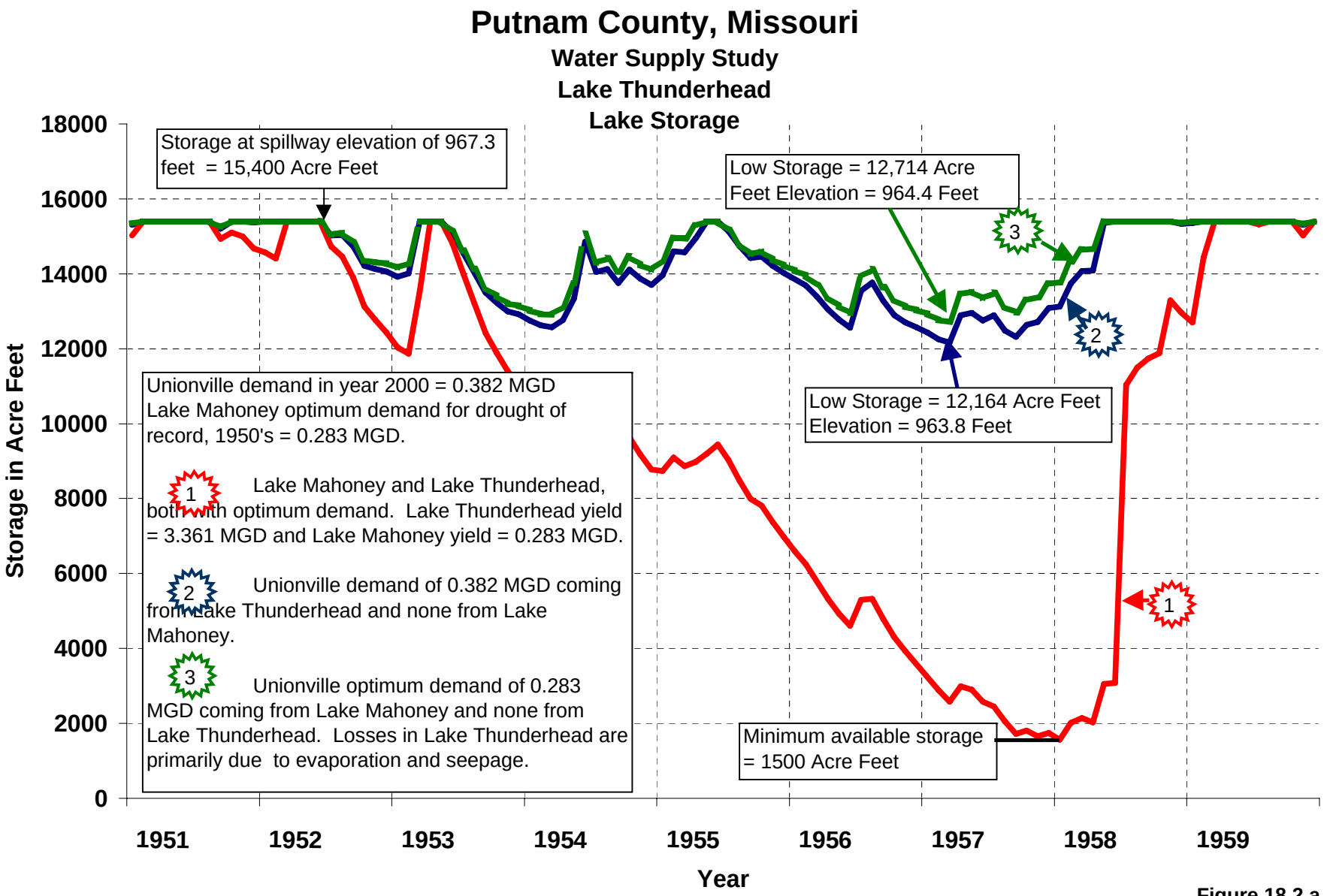

Putnam County, Missouri
Water Supply Study
Lake Thunderhead
Lake Storage
Storage at spillway elevation of 967.3 feet = 15,400 Acre Feet
Low Storage = 12,714 Acre Feet Elevation = 964.4 Feet
Low Storage = 12,164 Acre Feet Elevation = 963.8 Feet
Minimum available storage = 1500 Acre Feet
Unionville demand in year 2000 = 0.382 MGD
Lake Mahoney optimum demand for drought of record, 1950's = 0.283 MGD.
1 Lake Mahoney and Lake Thunderhead, both with optimum demand. Lake Thunderhead yield = 3.361 MGD and Lake Mahoney yield = 0.283 MGD.
2 Unionville demand of 0.382 MGD coming from Lake Thunderhead and none from Lake Mahoney.
3 Unionville optimum demand of 0.283 MGD coming from Lake Mahoney and none from Lake Thunderhead. Losses in Lake Thunderhead are primarily due to evaporation and seepage.
Storage in Acre Feet
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1951
1952
1953
1954
1955
1956
1957
1958
1959
Year

Figure 18.2.a

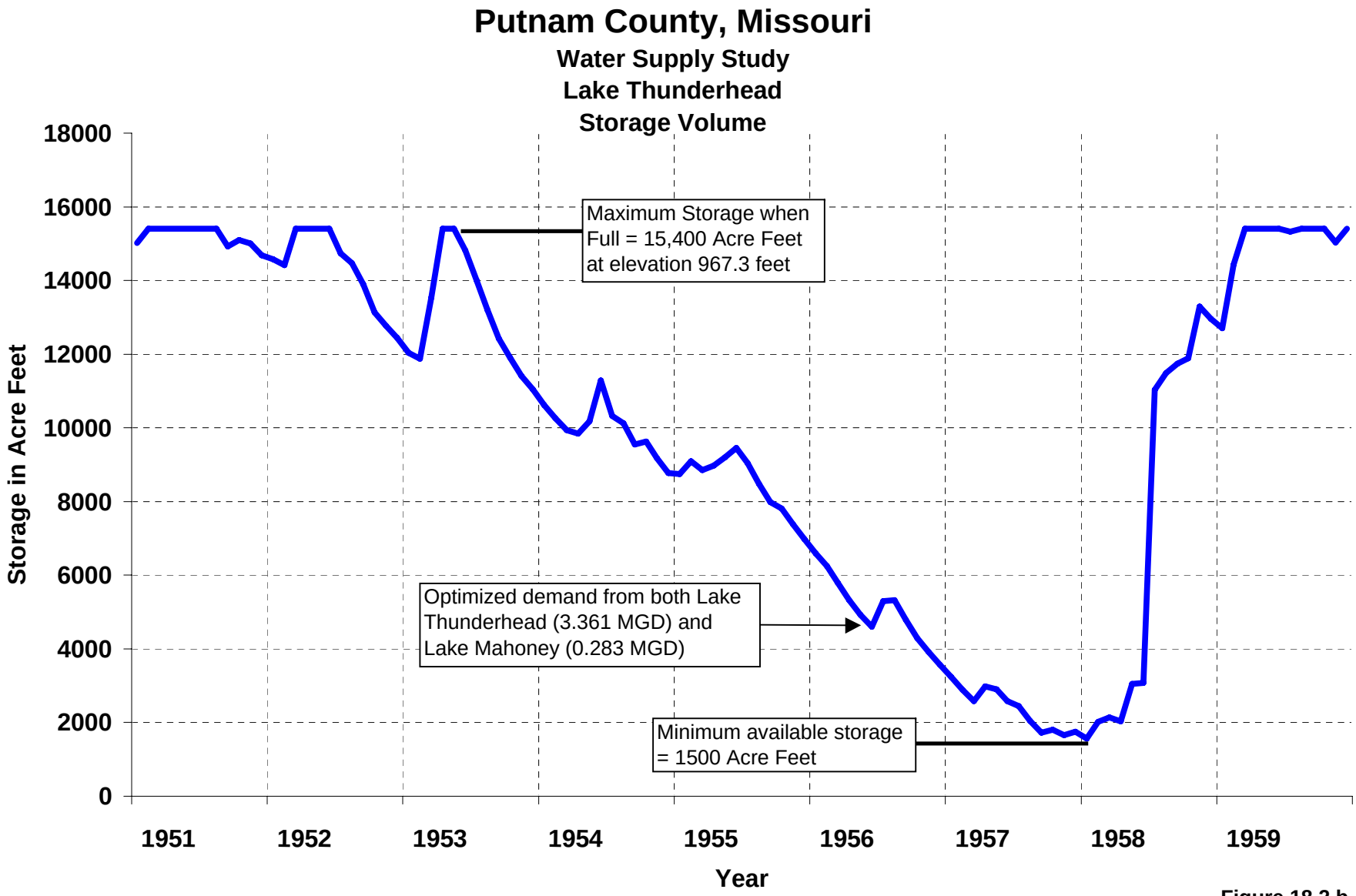

Putnam County, Missouri
Water Supply Study
Lake Thunderhead
Storage Volume
Storage in Acre Feet
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1951
1952
1953
1954
1955
1956
1957
1958
1959
Year
Maximum Storage when Full = 15,400 Acre Feet at elevation 967.3 feet
Optimized demand from both Lake Thunderhead (3.361 MGD) and Lake Mahoney (0.283 MGD)
Minimum available storage = 1500 Acre Feet

Figure 18.2.b

Putnam County, Missouri

Water Supply Analysis

Lake Thunderhead

Lake Storage

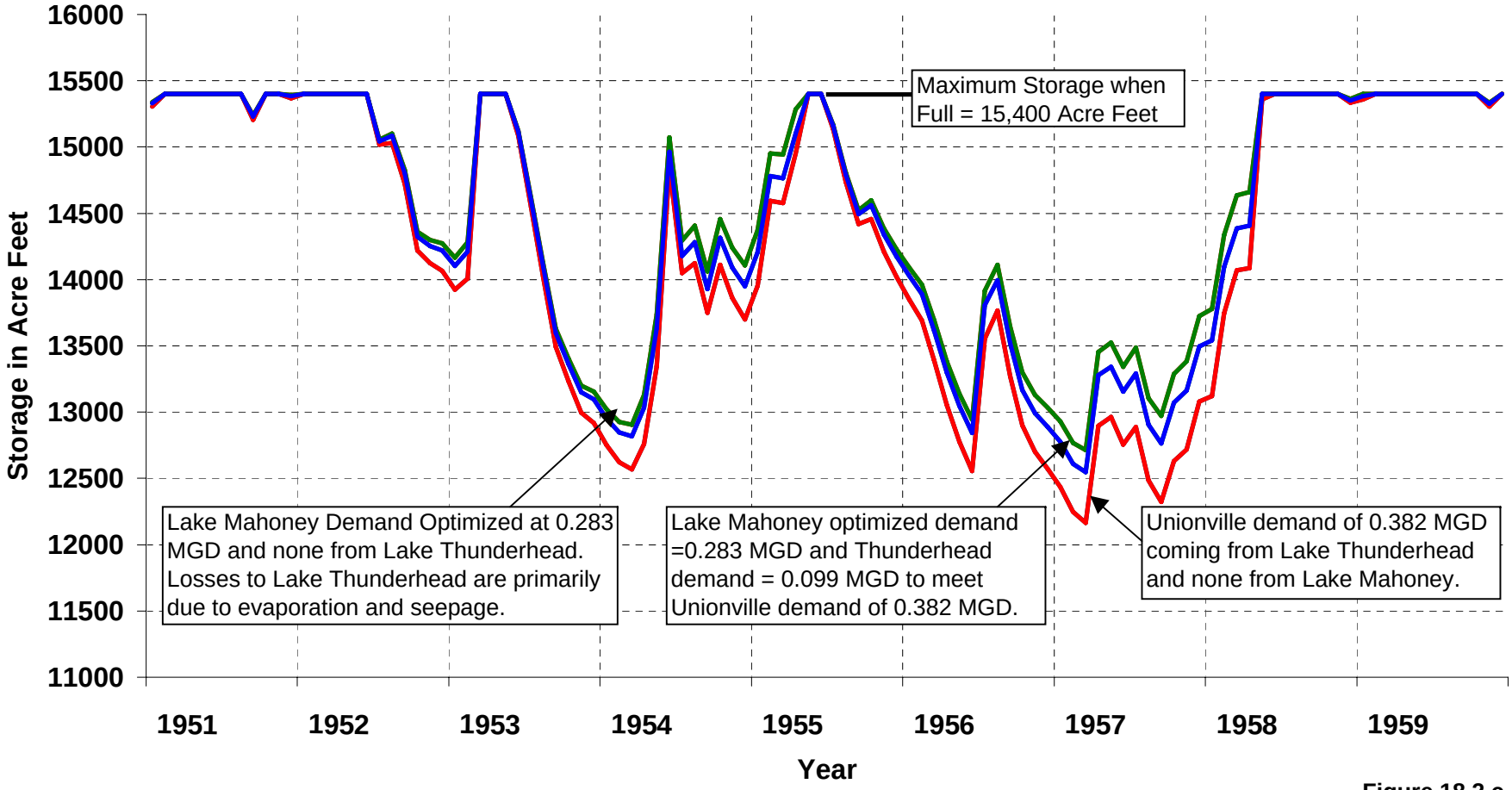


Figure 18.2.c

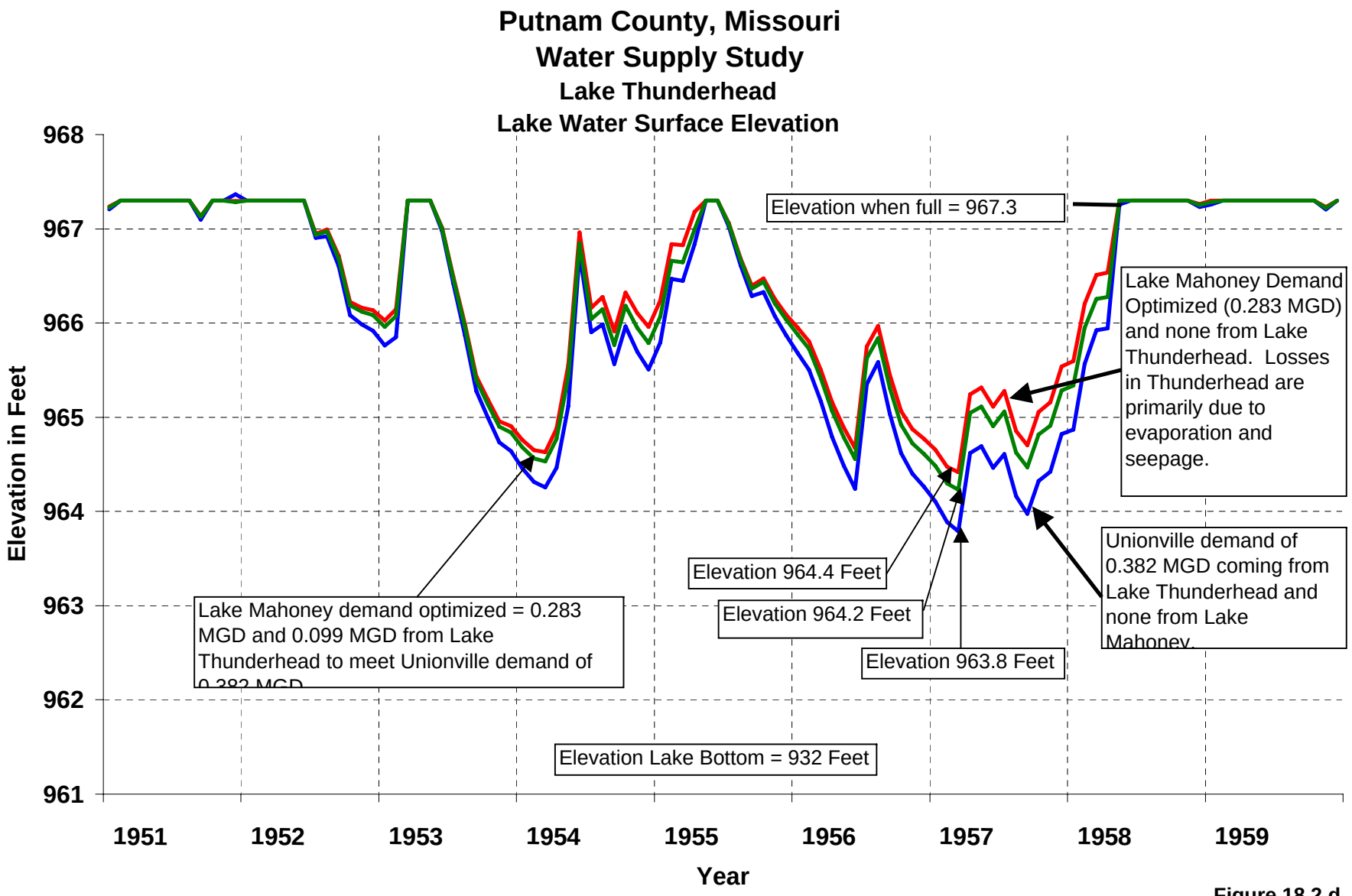

Putnam County, Missouri
Water Supply Study
Lake Thunderhead
Lake Water Surface Elevation
Elevation in Feet
968
967
966
965
964
963
962
961
1951
1952
1953
1954
1955
1956
1957
1958
1959
Year
Elevation when full = 967.3
Lake Mahoney Demand Optimized (0.283 MGD) and none from Lake Thunderhead. Losses in Thunderhead are primarily due to evaporation and seepage.
Unionville demand of 0.382 MGD coming from Lake Thunderhead and none from Lake Mahoney.
Elevation 964.4 Feet
Elevation 964.2 Feet
Elevation 963.8 Feet
Lake Mahoney demand optimized = 0.283 MGD and 0.099 MGD from Lake Thunderhead to meet Unionville demand of
Elevation Lake Bottom = 932 Feet

Figure 18.2.d

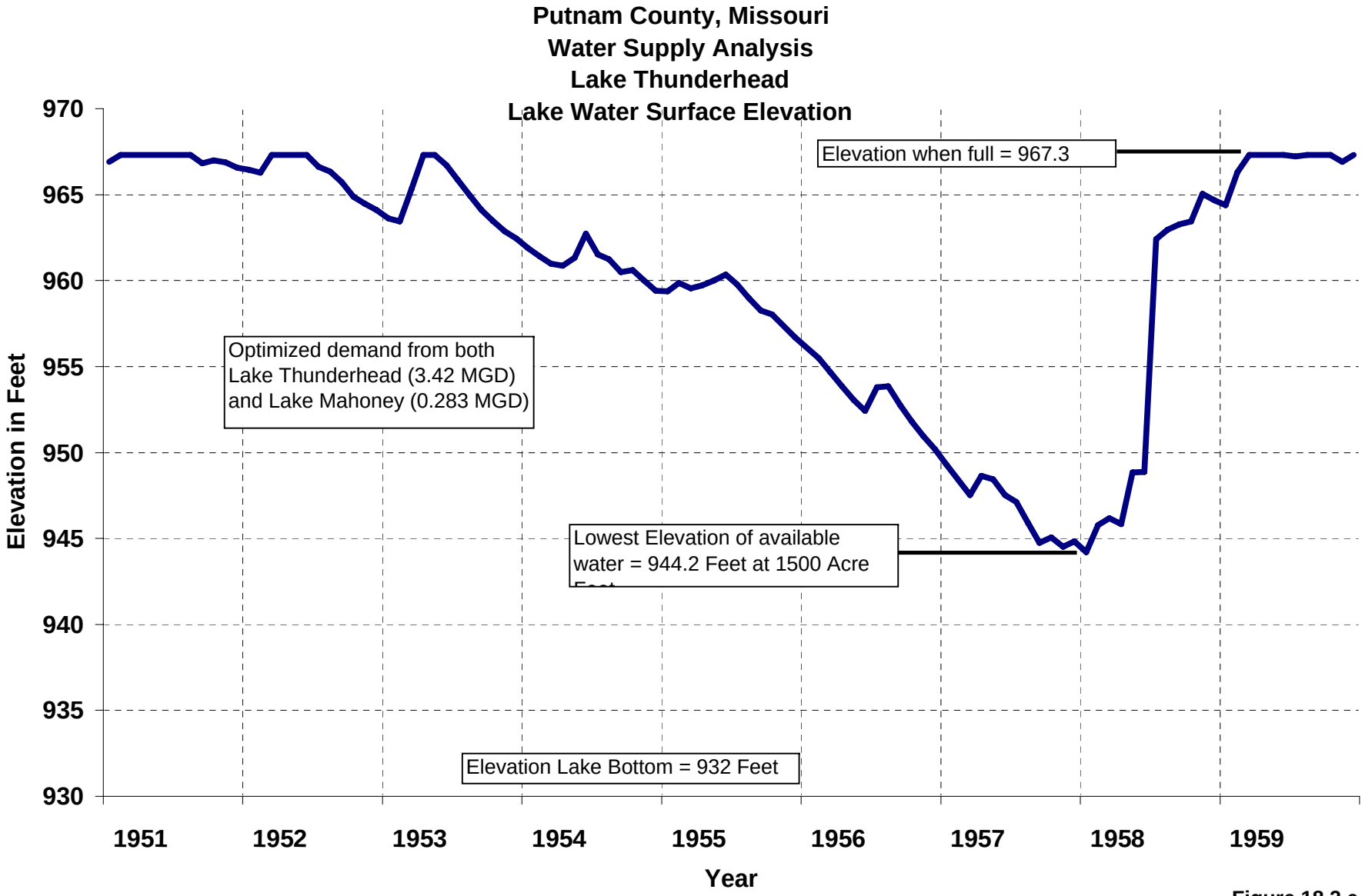

Putnam County, Missouri
Water Supply Analysis
Lake Thunderhead
Lake Water Surface Elevation
Elevation when full = 967.3
Optimized demand from both Lake Thunderhead (3.42 MGD) and Lake Mahoney (0.283 MGD)
Lowest Elevation of available water = 944.2 Feet at 1500 Acre
Elevation Lake Bottom = 932 Feet
Elevation in Feet
970
965
960
955
950
945
940
935
930
1951
1952
1953
1954
1955
1956
1957
1958
1959
Year

Figure 18.2.e

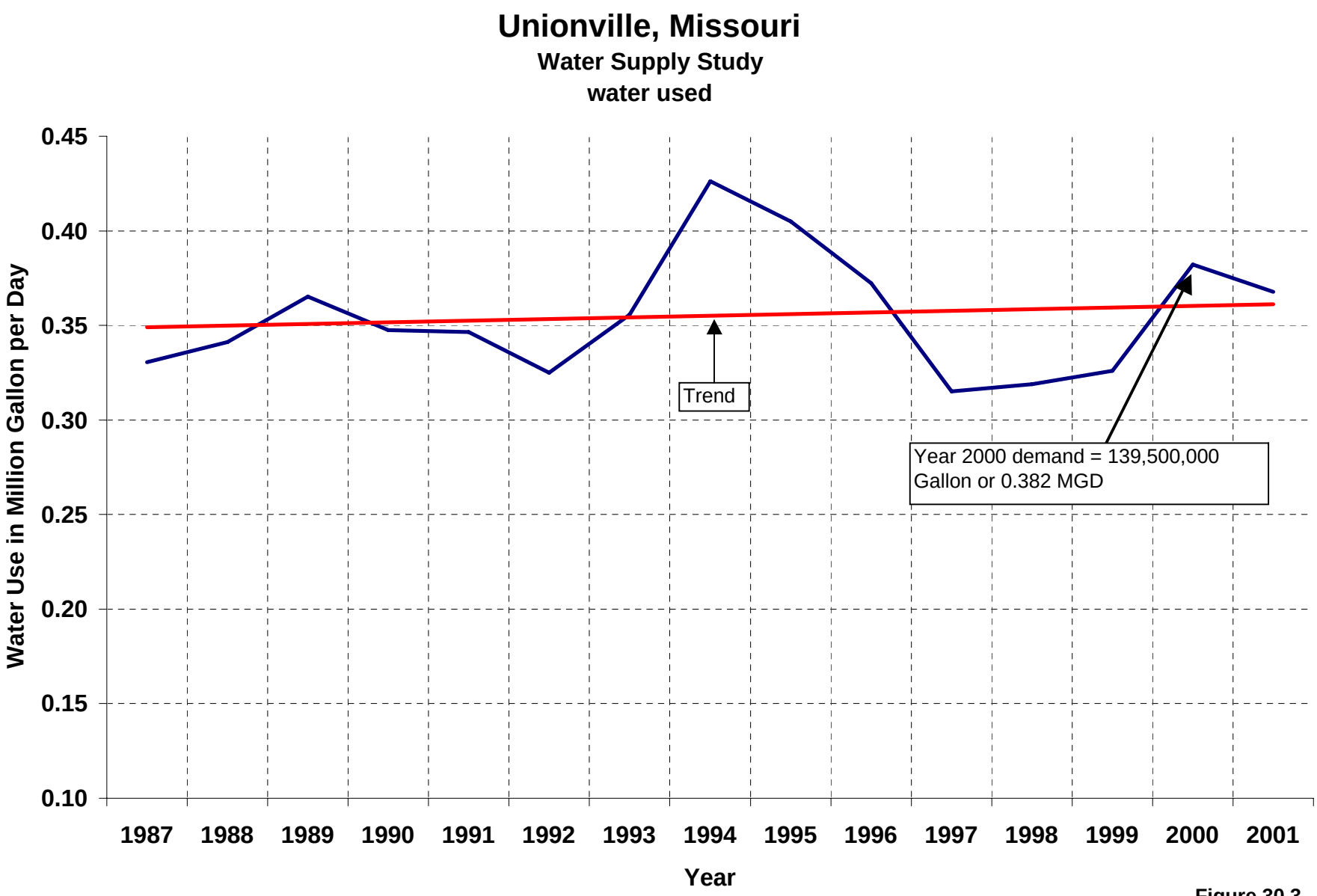

Unionville, Missouri
Water Supply Study
water used
Water Use in Million Gallon per Day
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Year
Trend
Year 2000 demand = 139,500,000
Gallon or 0.382 MGD

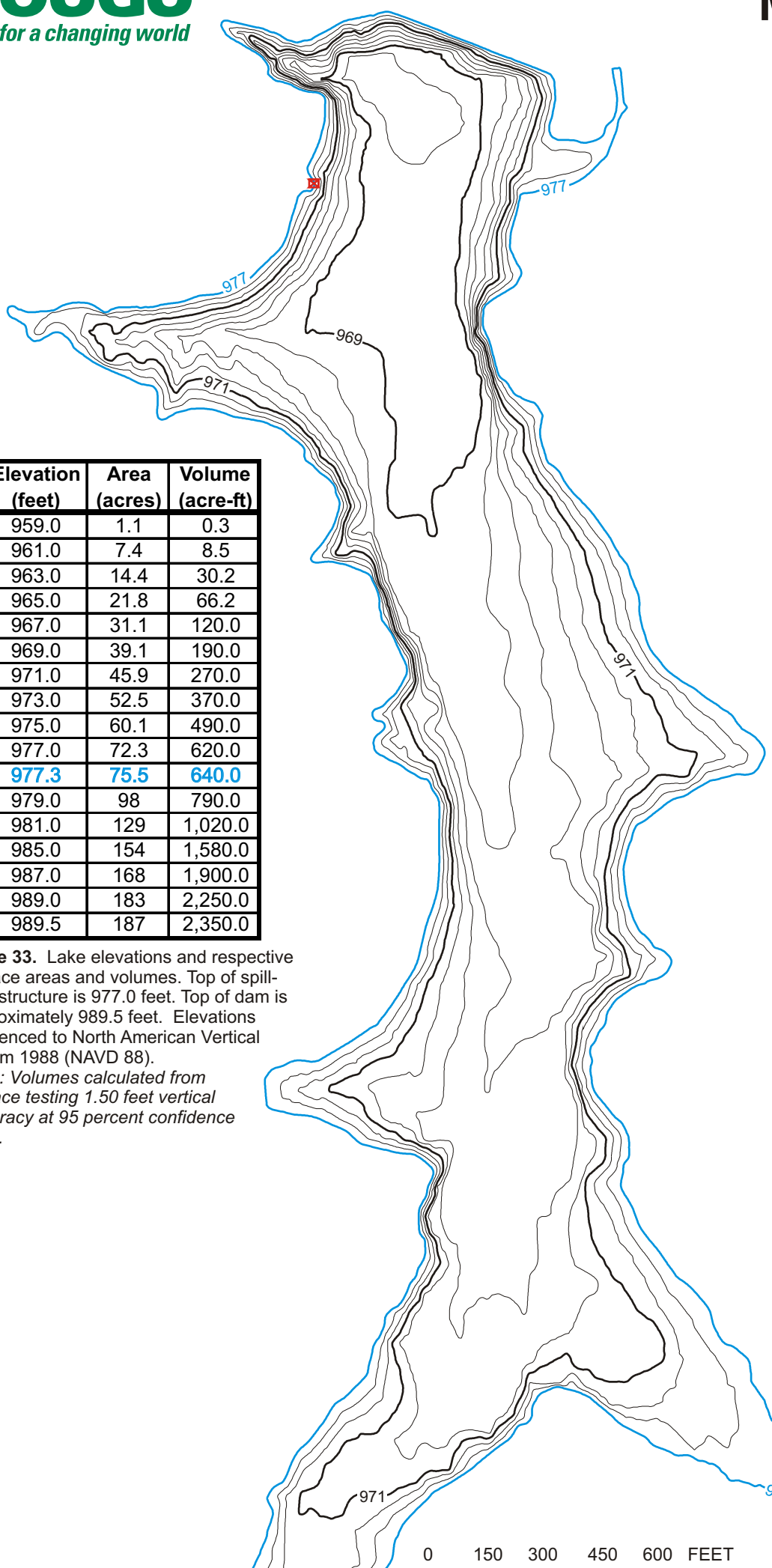
Figure 30.3

USGS
science for a changing world

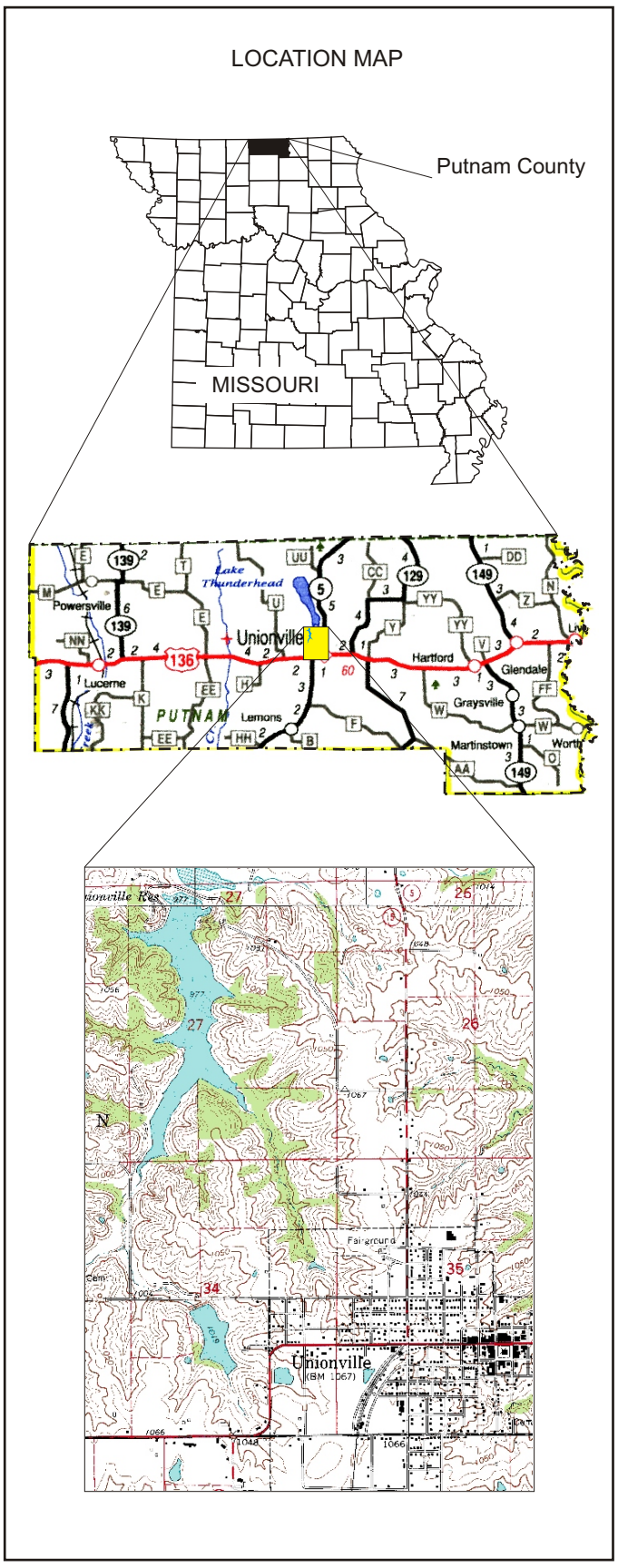
MAHONEY LAKE

Elevation (feet)	Area (acres)	Volume (acre-ft)
959.0	1.1	0.3
961.0	7.4	8.5
963.0	14.4	30.2
965.0	21.8	66.2
967.0	31.1	120.0
969.0	39.1	190.0
971.0	45.9	270.0
973.0	52.5	370.0
975.0	60.1	490.0
977.0	72.3	620.0
977.3	**75.5**	**640.0**
979.0	98	790.0
981.0	129	1,020.0
985.0	154	1,580.0
987.0	168	1,900.0
989.0	183	2,250.0
989.5	187	2,350.0

Table 33. Lake elevations and respective surface areas and volumes. Top of spillway structure is 977.0 feet. Top of dam is approximately 989.5 feet. Elevations referenced to North American Vertical Datum 1988 (NAVD 88).
Note: Volumes calculated from surface testing 1.50 feet vertical accuracy at 95 percent confidence level.



LOCATION MAP



EXPLANATION

971 — BATHYMETRIC CONTOUR—Shows altitude of the reservoir bottom. Contour interval 2 feet. Contours tested 2.47 feet vertical accuracy at 95 percent confidence level.

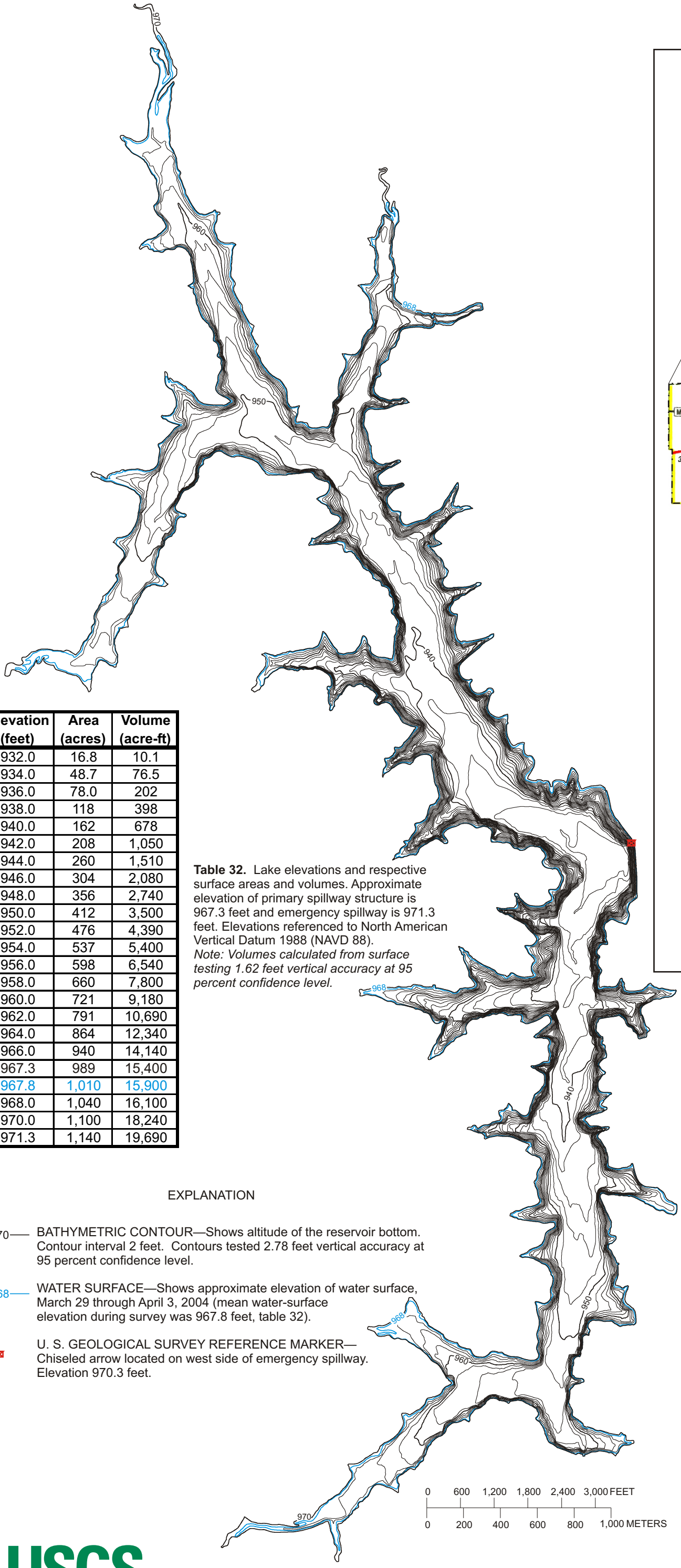
977 — WATER SURFACE—Shows approximate elevation of water surface, April 6, 2004 (actual is 977.3 feet, table 33).

U. S. GEOLOGICAL SURVEY REFERENCE MARKER—Chiseled arrow on curb located on north side of boat ramp. Elevation 977.4 feet.

Figure 28.4a Bathymetric map and table of areas/volumes of the Mahoney Lake near Unionville, Missouri.

In cooperation with Missouri Department of Natural Resources

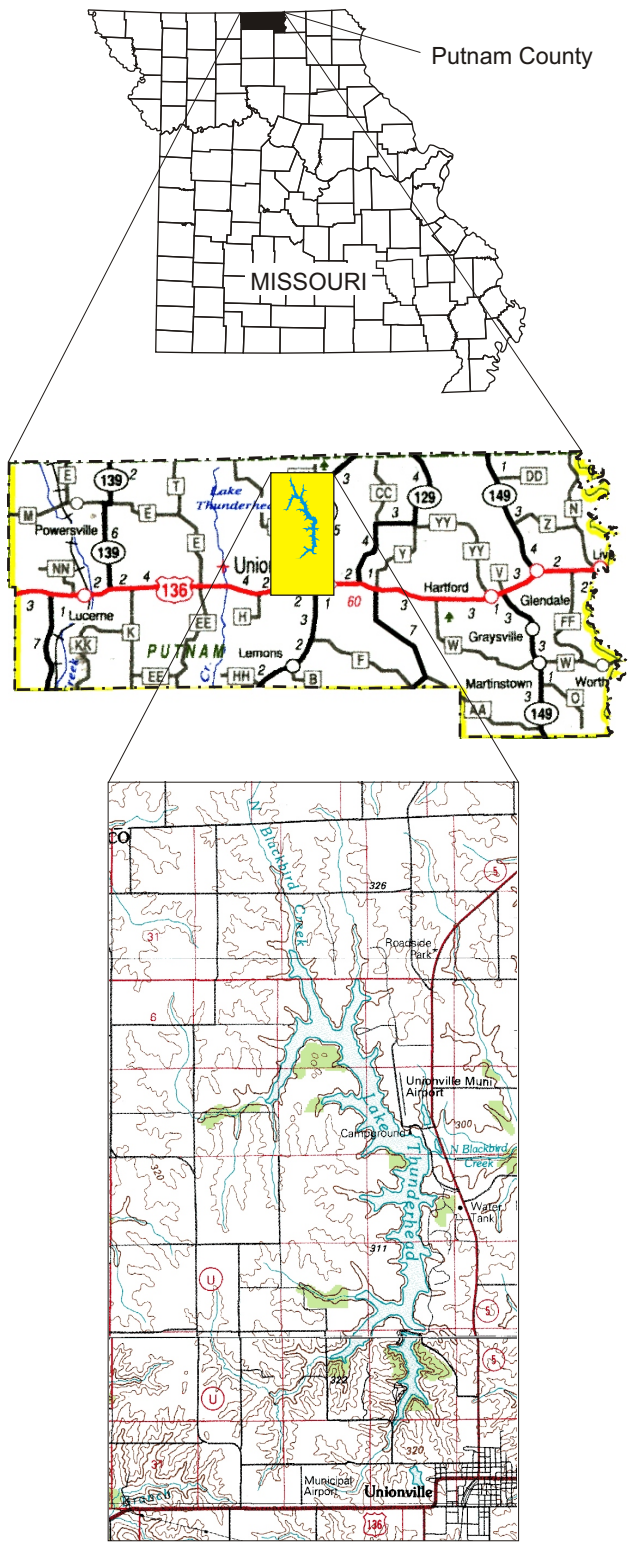
THUNDERHEAD LAKE



Elevation (feet)	Area (acres)	Volume (acre-ft)
932.0	16.8	10.1
934.0	48.7	76.5
936.0	78.0	202
938.0	118	398
940.0	162	678
942.0	208	1,050
944.0	260	1,510
946.0	304	2,080
948.0	356	2,740
950.0	412	3,500
952.0	476	4,390
954.0	537	5,400
956.0	598	6,540
958.0	660	7,800
960.0	721	9,180
962.0	791	10,690
964.0	864	12,340
966.0	940	14,140
967.3	989	15,400
967.8	1,010	15,900
968.0	1,040	16,100
970.0	1,100	18,240
971.3	1,140	19,690

Table 32. Lake elevations and respective surface areas and volumes. Approximate elevation of primary spillway structure is 967.3 feet and emergency spillway is 971.3 feet. Elevations referenced to North American Vertical Datum 1988 (NAVD 88).
Note: Volumes calculated from surface testing 1.62 feet vertical accuracy at 95 percent confidence level.

LOCATION MAP



EXPLANATION

970 — BATHYMETRIC CONTOUR—Shows altitude of the reservoir bottom. Contour interval 2 feet. Contours tested 2.78 feet vertical accuracy at 95 percent confidence level.

968 — WATER SURFACE—Shows approximate elevation of water surface, March 29 through April 3, 2004 (mean water-surface elevation during survey was 967.8 feet, table 32).

U. S. GEOLOGICAL SURVEY REFERENCE MARKER—Chiseled arrow located on west side of emergency spillway. Elevation 970.3 feet.

USGS science for a changing world

Figure 28.4b Bathymetric map and table of areas/volumes of the Thunderhead Lake near Unionville, Missouri.

In cooperation with Missouri Department of Natural Resources